
Space Weather Technical Forecast

Issued on Monday, 12 February 2024 at 12:23 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales <https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales>

Space Weather Forecast Headline: CME arrivals possible from late 12 Feb until early 14 Feb (day 1-3), with G1 Minor Storm intervals likely and a chance of G2 Moderate Storms. M-flares likely. S1 Minor solar radiation storm expected to continue day 1, perhaps into day 2.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Activity was Moderate with a peak flare M6.5 at 12/0348 UTC, from AR3576 in the southwest. An M1 flare was observed from a region just beyond the northeast limb 11/2245 UTC.

AR3576 remains the largest region, but has been losing small spots as it matures, although a small delta-spot has emerged to the north of the main leader spot, maintaining this region's complexity. AR3583 saw the most notable growth, with the development of strong leader and trailer spots, along with a number of smaller intermediate spots, while AR3582 had some small flux emergence occur to its north. There are seven regions currently on the disc, however all other regions are smaller and simpler. Two further regions are expected to soon rotate into view from the eastern solar horizon.

No Earth directed CME's (coronal mass ejections) were observed, however a significant far-sided eruption produced a large and fast CME from beyond the southwest limb. Initial analysis has been undertaken, and although model results are pending, the resulting CME is expected to be well off the Sun-Earth line.

Solar Wind / Geomagnetic Activity: Solar winds showed ongoing CME influence, initially mainly between 550-620 km/s, peak 648 km/s, but have reduced erratically since midnight UTC, dipping 490-500km/s at times. Density was at average or just above average levels, with a slight downward trend since midnight UTC. Interplanetary Magnetic Field (IMF) Bt, was weak 4-8nT, with a similar trend as above. The north-south component, Bz, varied between +7nT and -6nT. Phi angle was negative (towards the Sun). Geomagnetic activity was Quiet (Kp 1-2).

Energetic Particles / Solar Radiation: GOES18 high energy (greater than 10MeV) proton flux started the period above the S1 Minor Radiation Storm level, but fell below at 11/1805 UTC. However, the S1 Minor Radiation Storm level was breached again soon after 12/0800Z, rising to a current peak of 571 pfu at 12/1140UTC. 100Mev proton flux touched the 1pfu level at 12/1015 and 12/1050UTC otherwise remained just below.

GOES16 high energy (greater than 2MeV) electron flux remained at background. The associated 24-hour fluence was well below the Active (1e8 integrated pfu) threshold and has had a flat trend, with a 12/0000UTC fluence value of 1.55e6 pfu observed.

Four-Day Space Weather Forecast Summary

Solar Activity: Moderate activity likely to persist with further M-flares, and a slight chance of X-

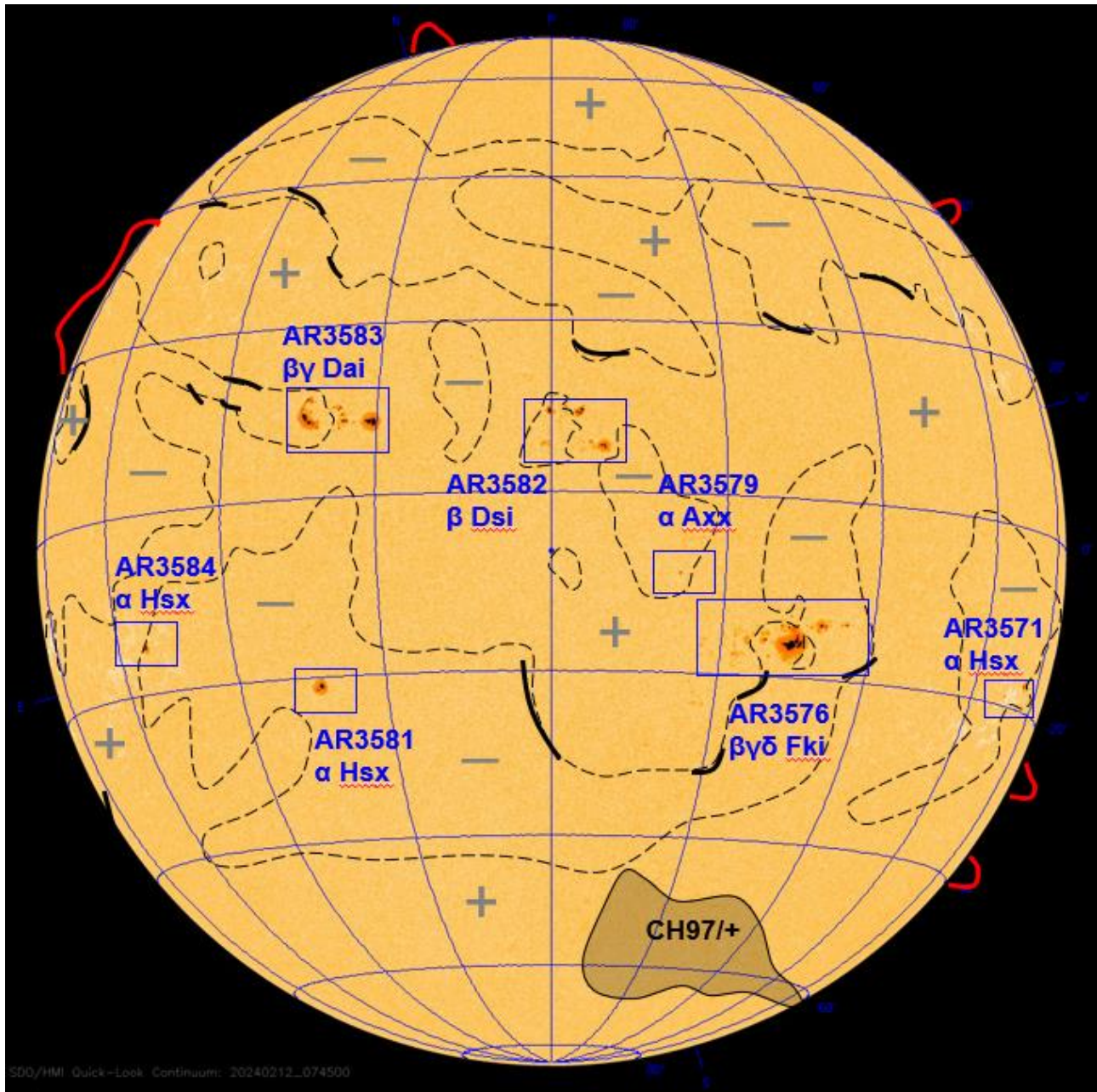
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flares. These perhaps most likely from AR3576 in the southwest, but with an increasing potential from developing AR3582 and AR3583, along with new regions moving onto eastern disc.

Solar Wind / Geomagnetic Activity: Multiple CME arrivals are possible day 1-2 (12-13 Feb) with ongoing effects likely day 3 (14 Feb). Otherwise current elevated winds are likely to gradually ease day 1 (12 Feb), before any CME enhancements occur. Any enhanced solar wind environment then easing day 4 (15 Feb). Mainly Quiet geomagnetic conditions at first are likely to become Active with a chance of G1 Minor Storms day 1, and likely rising to G1 Minor Storm with a chance G2 Moderate Storms day 2 (12-13 Feb). These conditions continuing day 3 (14 Feb) before easing to mainly Quiet day 4 (15 Feb).

Energetic Particles / Solar Radiation: GOES18 high energy (greater than 10MeV) proton flux has become enhanced again following a large far-sided flare and CME eruption from beyond the southwest limb. The S1 Minor Radiation Storm level was breached soon after 12/0800Z and is now expected to continue at S1 levels for much, if not all of the rest of day 1 (12 Feb), perhaps continuing into day 2 (13 Feb). Further enhancements are possible associated with potential CME arrivals from later day 1 into day 2, along with any significant flares from AR3576. High energy electron flux (greater than 2MeV) is expected to continue at background, with the associated 24-hour electron fluence remaining well below the Active threshold.

Figure 1. Solar Analysis Valid 12/0800 UTC.



Key: Filament ____, Prominence ____, Magnetic Field Line - - -, Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

Geomagnetic Storms:

There are three CMEs which may have Earth-directed impacts, and dominate the geomagnetic forecast for this period.

The first is a CME associated with the 08/2030 UTC south-centre filament eruption. This is modelled as crossing 1AU, mainly behind and below the Sun-Earth line late on day 1 (12 Feb) or early on day 2 (13 Feb). The second due the long period C-class flare of AR3579 and an associated filament eruption from 10/0700 UTC. This has been analysed as Earth-directed, possibly arriving during the first half of day 2 (13 Feb). These two CMEs may also combine to give a single arrival.

The third is from the AR3576 M9.0 flare 10/2100 UTC. This is a complex eruption near centre disc, resulting in a broad partial halo shock, but with the material appearing to be deflected mainly north-west. There is low confidence in the extent of any impact, with much of the material directed north and east, however this is likely to arrive later on day 2 (13 Feb), or early day 3 (14 Feb). Any arrival may combine with the previous impacts however, leading to further enhanced response.

Solar winds are then expected to gradually ease day 3 onward, and with CH96/+ to the far south, no coronal hole enhancements are expected in this period.

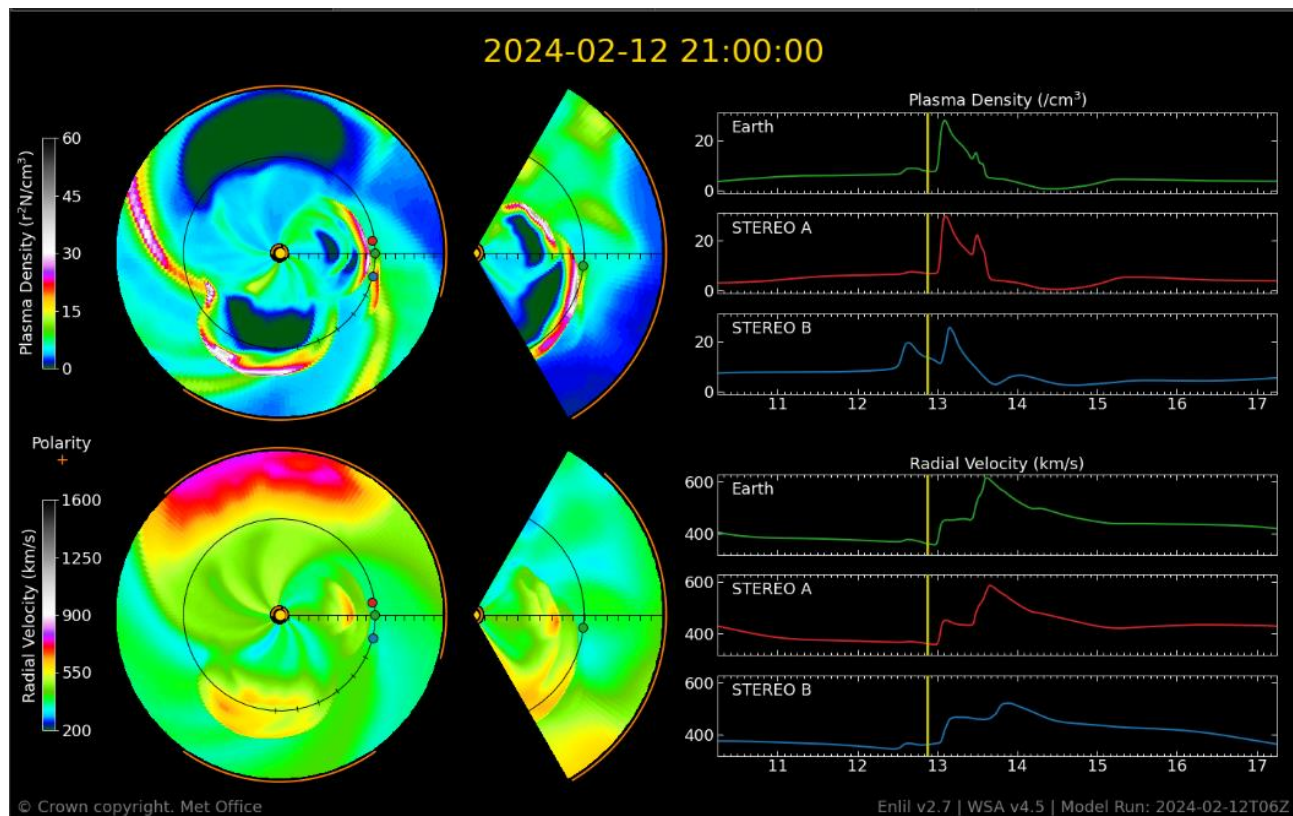
Initially Quiet geomagnetic activity with a chance of isolated Unsettled intervals as the influence of the CME arrival early on 11 Feb continues to ease. This becoming Active with a chance of G1 Minor Storm intervals, with the CME arrival late day 1 or early day 2 (12-13 Feb). Further CME arrivals on day 2 and into day 3 (13-14 Feb), bring a likelihood of G1 Minor Storm intervals and a chance of G2 Moderate Storms. Any combined impacts bring a slight chance of G3 Strong Storms. CME influence will then ease later day 3 onward (14 Feb), with activity becoming mainly Quiet with isolated Unsettled spells day 4 (15 Feb).

Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	No	25	60	40	1
Strong	G3	No	5	15	10	1
Severe	G4	No	1	2	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
09/0113	Nil	Filament	S-centre	641 km/s	Late 12 Feb/early 13 Feb	Low confidence, mainly missing south
10/1040	Nil	Filament and C-flare AR3576	S-centre	890 km/s	Early 13 Feb	Mainly passing south
11/0330	Partial shock	M9 AR3576	SW but directed NW	810 km/s	Late 13 Feb	Complex eruption – low confidence with material heading NE

Figure 2: MOSWOC Enlil showing potential CME arrivals.



Radio Blackouts - X-Ray Flares:

Mainly Moderate activity is likely to continue through the period, with seven sunspot regions currently on the disc, including the large but maturing AR3576, but also two further developing regions AR3582 and AR3583. There is a slight chance of X-class flares.

The declining trend of large region AR3576 appears to have stalled. This region is primarily comprised of negative polarity spots, however this maintains a complex structure due to a small positive polarity spot to the north of the large leader. Strong flares remain possible due to the strength of the magnetic flux of the main leader. Growth has been observed to the north of AR3582, near north-centre, and more notably in the intermediate region of AR3583 in the northeast, and these both have an increasing chance of notable flare activity.

New regions are also expected to soon rotate onto the east disc, with looping evident over both the northeast and southeast limbs, and one of these was the source of the M1.0 flare at 11/2245 UTC. These will also bring a risk of further M-flares.

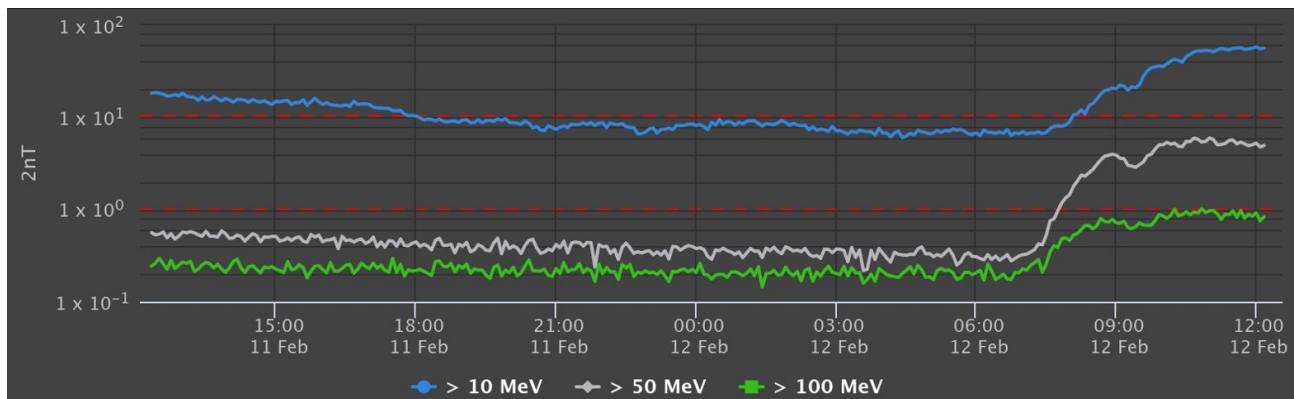
X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	75	75	75	75
Very Active	R3 to R5 X Class	No	15	15	15	15

Solar Radiation Storms - (High Energy Protons):

GOES18 high energy (greater than 10MeV) proton flux has become enhanced again following a large far-sided flare and CME eruption from beyond the southwest limb. The likely source being ex-3575. The S1 Minor Radiation Storm level was breached soon after 12/0800Z and is now expected to continue at S1 levels for much, if not all of the rest of day 1 (12 Feb), perhaps continuing into day 2 (13 Feb). Further enhancements are possible associated with potential CME arrivals from later day 1 into day 2, along with any significant flares from AR3576.

Radiation Storms	Level (cm ⁻² sr ⁻¹ s ⁻¹)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ S1	Yes	100	60	30	15
Very Active	≥ S3 *	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = cm⁻²sr⁻¹s⁻¹)

Figure 3: GOES-18 Proton flux

High Energy Electrons Event ($\geq 2\text{MeV}$):

High energy electron flux (greater than 2MeV) as observed by GOES16 is expected continue at mainly background. There are no coronal hole enhancements forecast, however multiple CME arrivals will also likely disturb the Van Allen belts through day 1-3 (12-14 Feb). These may see some increased electron population, but will likely compress inside of GEO. As solar wind pressure eases later day 3 and more likely day 4, the Van Allen belts are likely to relax back to GEO. This may result in periods of Moderate, and a very slight chance of reaching High flux. The associated 24-hour electron fluence is expected to remain well below the Active ($1\text{e}8$ integrated flux) threshold, as suggested by MOSWOC REFM, however this is likely to become less reliable through the period due to the arrival of a number of CMEs.

GEO Electron Environment	Level ($\text{cm}^{-2} \text{sr}^{-1} \text{day}^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	$\geq 2 \text{ MeV}$ $\geq 1 \times 10^8$	No	1	1	1	5
Very Active	$\geq 2 \text{ MeV}$ $\geq 1 \times 10^9$	No	1	1	1	1